Hurricane Hardening Research

Presentation to the Louisiana Public Service Commission

May 4, 2007

Mark A. Jamison, PURC Director

UF | Public Utility Research Center
UNIVERSITY of FLORIDA

"Leadership in Infrastructure Policy"

www.purc.ufl.edu

Overview

- Background on PURC
- Impetus for Hurricane Hardening Research Coordination
- Research Projects

PURC Background

- Founded in 1972
- Located in the Economics Department, Warrington College of Business Administration
- Purpose: Enhance executives', regulators', academics', and students' knowledge of issues confronting public utilities and regulatory agencies
- Support: Utilities and FPSC, programs, and research

PURC Research, 2002-2006

Type	Number			
	Intl.	Domestic	Either	Total
Applied Journals	9	6	8	**23**
Academic Journals	5	10	19	**34**
Books			1	**1**
Book Chapters	2	2	13	**17**
Working Papers	9	20	20	**49**
Case Studies	2	2		**4**

PURC Recent and Ongoing Research Topics

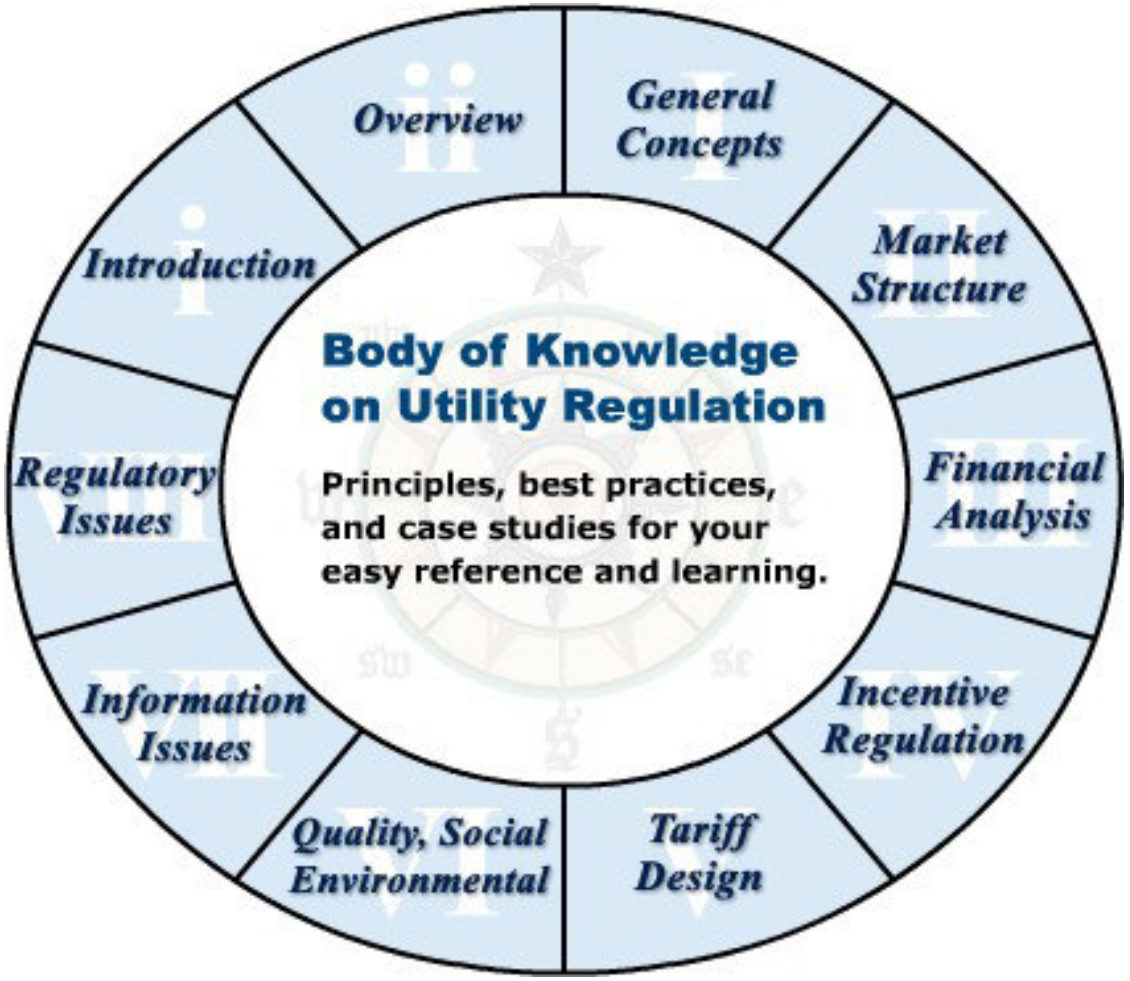
General
- Service Quality
- Leadership
- Body of Knowledge
- Regulatory Associations
- Stability of Regulatory Institutions
- Regulatory Risk

Energy
- Distributed Generation
- Pricing and Rate Design
- NOx, SO2, and Climate Change Policy
- Fuel Diversity and Policy Uncertainty

Telecoms
- Telecom Competition
- Ownership of Utility Services
- Universal Service Programs
- Net Neutrality

Water
- Benchmarking Water Utilities in Central America

Body of Knowledge on Utility Regulation
visit www.regulationbodyofknowledge.org



UF | Public Utility Research Center
UNIVERSITY of FLORIDA

"Leadership in Infrastructure Policy"

www.purc.ufl.edu

PURC Programs

Domestic

- PURC Annual Conference
- Leadership workshops
- Roundtables
- Bar Association Conf.

International

- PURC/World Bank International Training Program
  - > 1700 people; 131 countries
- PURC/OOCUR Advanced Training Program

International (Cont.)

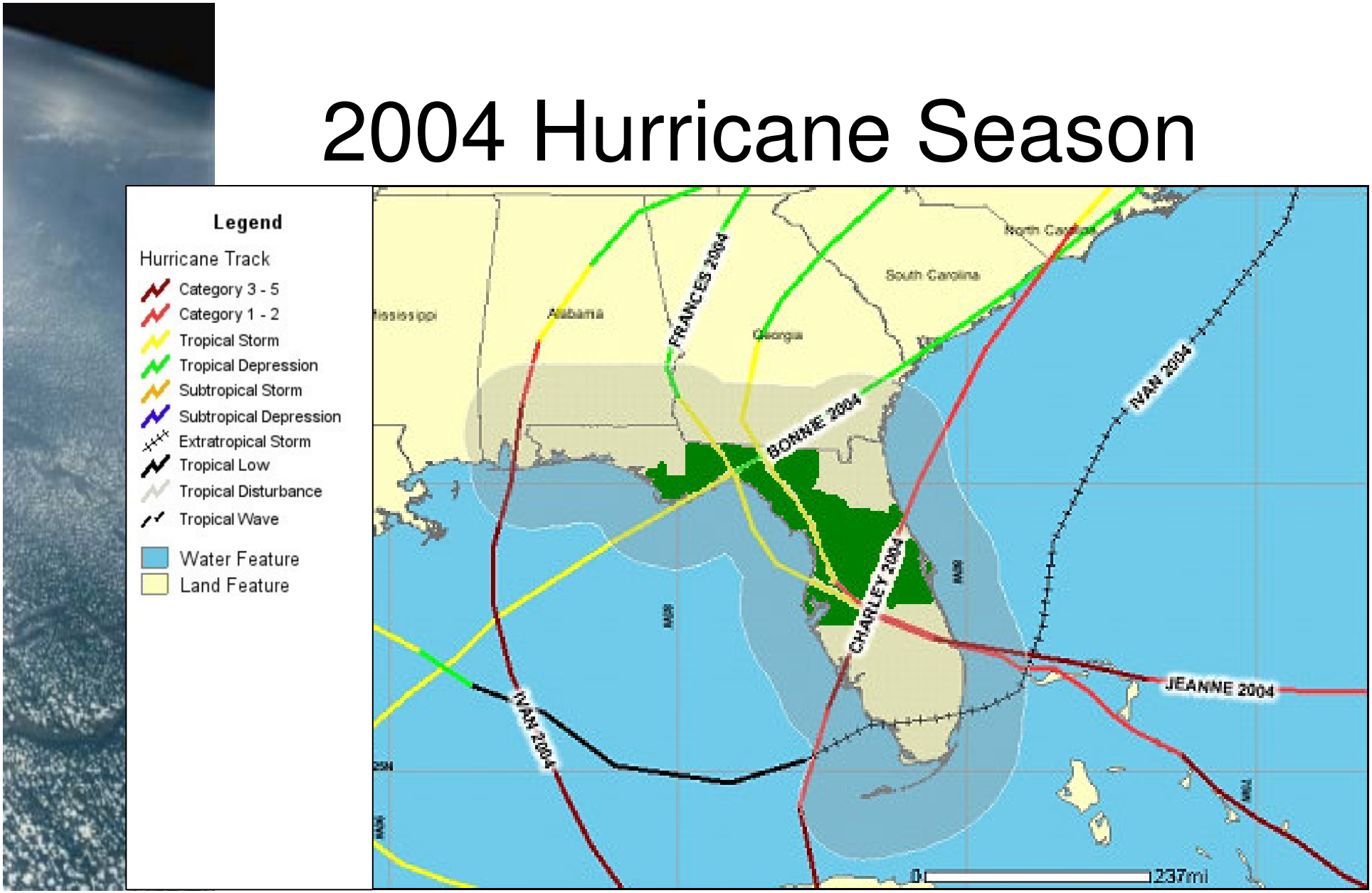
- Standing Cooperative Programs – University of Cape Town, IIS-Zambia
- Recent Custom Training Programs and Other Outreach
  - Telecoms – Thailand, Trinidad & Tobago, Nigeria, Uganda
  - Energy – Cambodia, Peru, South Africa, Brazil, Mexico, Namibia
  - Water – Uganda, China

Impetus for Hurricane Hardening Research


Welcome to Florida
We are here
www.tonypavone.com


Destruction to overhead lines, Pensacola Beach
Source: Gulf Power

2004 Hurricane Season



2004 Storm Season Impacts Progress Energy Florida Summary

45 Days, 4 Hurricanes…
23 Days of Restoration Activity

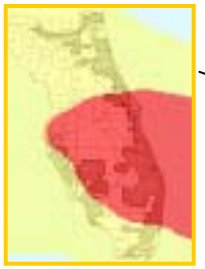
	Charley	Frances	Ivan	Jeanne
Date of landfall	Aug. 13	Sept. 5	Sept. 16	Sept. 26
Category at peak	Cat 4	Cat 2	Cat 3	Cat 3
Peak number of customers out	502,000	832,898	10,000	722,000
Substations out	83	105	3	86
Days of storm restoration	10 Days	7 Days	1 Day	5 Days

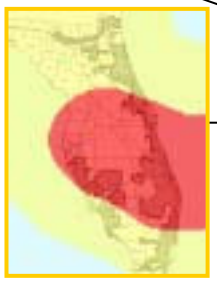
2004 System Impact, TECO

	Charley	Frances	Jeanne
Distribution			
Circuits Out	68	223	252
Lights Out	353	2519	639
Wire Down (spans)	2,540	5,780	6,600
Transmission			
Circuits Out	17	21	42
Wire Down (spans)	74	34	151
Substations			
Distribution Out	23	46	70
Transmission Out	17	21	42

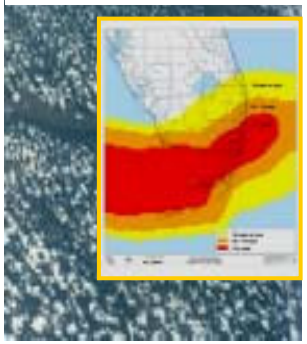
Storm Season 2004-2005, FPL
7 Storms / 15 Months

2004 Season





2005 Season



Event	Affected Customers	Days to Restore 100%
Charley	874,000	13
Frances	2,786,300	12
Jeanne	1,737,400	8
Dennis	508,800	3
Katrina	1,453,000	8
Rita	140,000	2
Wilma	3,241,437	18

Hurricane force winds

Tropical storm force winds

Source: FPL

FPL 2005 - Distribution and Transmission Repair

- **Distribution**
  - 12,632 poles (FPL & non-FPL)
  - 930 miles of OH conductor
  - 570 miles of OH service conductor
  - 1.1 million OH splices
  - 30 miles of UG cable
  - 100 miles of UG service cable

- **Transmission / Substation**
  - 100 structures
  - 7 miles of conductor
  - 1 substation transformers
  - 7 regulators
  - 16 breakers

Source: FPL

FPSC Response

- Workshops with utilities, consultants, and academics on how best to prepare Florida's electric infrastructure for hurricanes
- New standards
- Ongoing monitoring and reporting

http://www.psc.state.fl.us/utilities/electricgas/eiproject/

FPSC 9-Point Preparedness Plans

- 3-year vegetation management cycles
- Trans. and distribution geographic info system
- Upgrade wooden structures
- Data gathering, retention, and forensic analysis
- Audit joint-use pole attachment agreements
- 6-year transmission inspection program
- Track outage data for overhead vs. underground
- More utility coordination with local government
- Collaborative research coordination

Why Research Coordination?

- Concerned that utilities were generally unaware of each other's research efforts
- Desire to increase focus on hardening research
- Interest in making research results generally available

Research Approach

Research Coordination Effort

- Sponsored by all electric utilities in the state and governed by Steering Committee
  - IOUs: FPL, Progress, Gulf Power, TECO, FPU
  - Municipal Association
  - Coop Association
  - Lee County Electric Cooperative
- PURC coordination
  - Manage process; review research plans and products for academic standards

Workshop, June 9, 2006

- Utility managers
  - Review of hurricane experiences and key knowledge gaps
- Researchers
  - Research experiences and capabilities
    - UF, FSU, USF, Texas A&M, Cornell, Davies Consulting, Applied Research Associates

Workshop Conclusions

Practical research needed on

- Wind measurement and testing
- Improved materials
- Forensic analysis
- Cost-effectiveness of approaches
  - Overhead vs. underground
  - Vegetation management
  - Wind standards
- Joint use loads

Research Agenda

- Economics of Undergrounding Existing Overhead Facilities
  - Addresses cost-effectiveness issue
- Granular Wind Analysis
  - Addresses wind measurement and testing, forensic analysis, and standards
- Vegetation Management best practices

http://bear.cba.ufl.edu/centers/purc/energy/hurricane.htm

Undergrounding Research

- Launched in Fall 2006
- Consultant: InfraSource (Richard Brown)
- Phases
  - I – Meta-analysis of existing literature to see what is already known (completed)
  - II – Case studies on what might be unique about Florida (underway)
  - III – Computer model to project costs/benefits of specific undergrounding requests (starts in June)

Undergrounding and Storm Surge

Pensacola Beach: Single Phase cabinet washed off pad and cables pulled out of terminations.

Source: Gulf Power

Meta-Analysis

- Examined 61 documents
  - Consultant Reports
  - State Regulatory Reports
  - Municipal Reports
  - International Reports
  - System Reliability Modeling
  - Failure Rate Modeling
  - Property Value
- Primary Issues
  - Cost
  - Benefits
  - Disadvantages
  - Funding

Source: InfraSource

Meta-Analysis Executive Summary

Existing Studies show:

- Undergrounding has both benefits and disadvantages
- Quantifiable benefits cannot justify undergrounding
- Undergrounding is expensive
  - About $1 million per mile (initial cost)
  - Customer service work costs extra
  - Cost can vary widely
  - Broad implementation requires rates to about double
- Undergrounding requires additional costs
  - Third-party attachments (add 25% to initial cost)
  - Customer equipment ($1,500 to $7,000 per customer)
  - Funding additional costs is a critical element
- Funding in general is a critical element

Other Findings

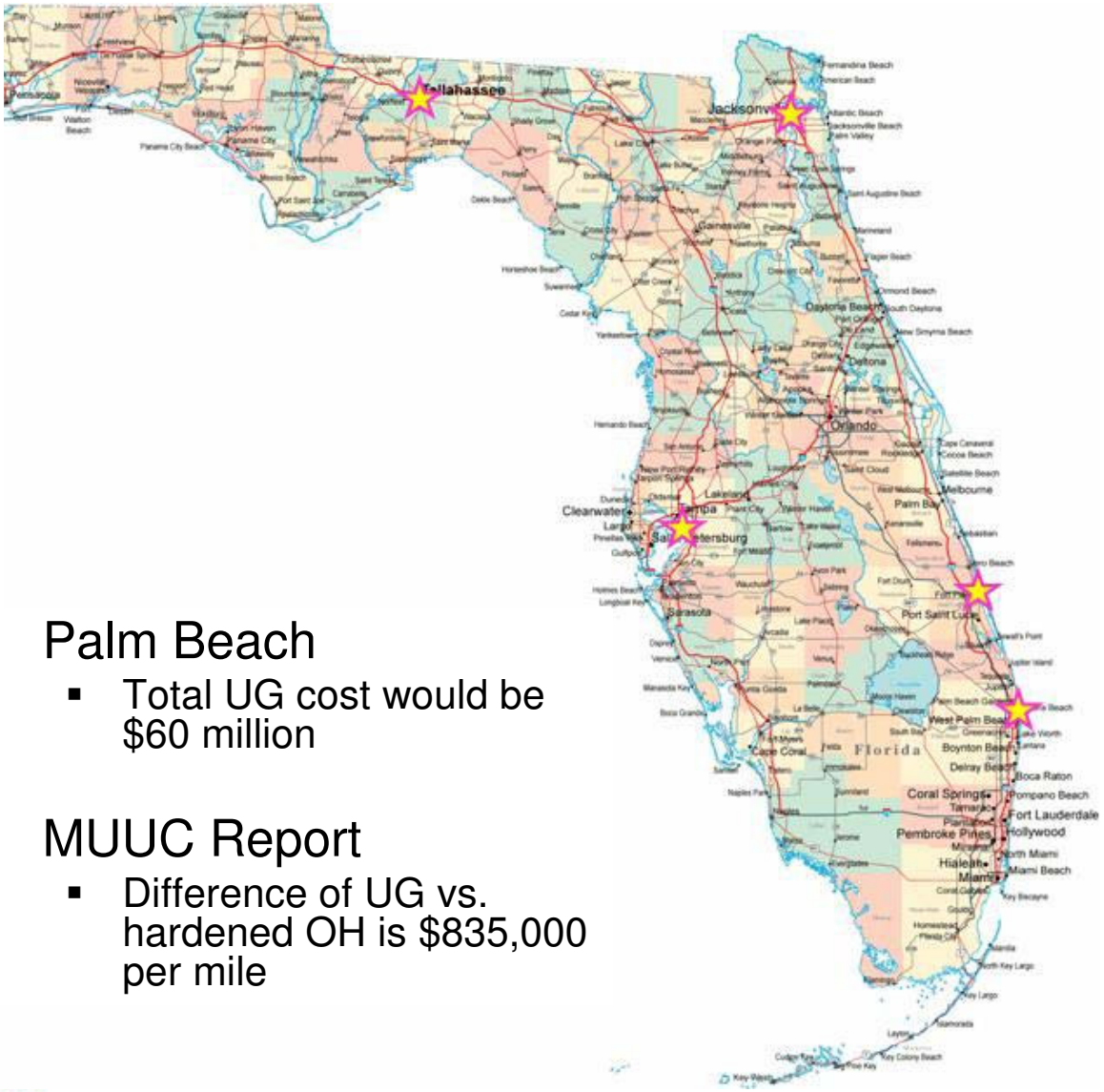
- No state requires undergrounding of existing facilities
- *Ex post* analyses on actual UG projects have not been done
- Few studies address negative impacts
- Few studies consider strengthening existing overhead systems
- Storm reliability models are almost non-existent
- Equipment failure rates as a function of hurricane strength are almost non-existent
- Existing research on mitigating the impacts of major storms on electric distribution is not sufficient for use in a detailed study

Florida 2005 FPSC Study

- Conversion Cost Estimates (IOUs)
  - Residential subdivision: $2,475 per customer affected
  - Residential feeders: $11,288 per customer affected
  - Mainline urban commercial: $36,737 per customer affected
- Costs do not include
  - Customer service equipment
  - Third-party attachments
- Rate impact
  - 81% increase if spread over all customers
  - 141% increase if spread over residential customers only

Florida Studies

- Davis Island
  - $3,200 per customer for a 3000 customer project
- Fort Pierce
  - Broad conversion is not justifiable
  - Overhead hardening may be preferable
- Jacksonville
  - $3,000 to $7,000 per customer
- Tallahassee
  - High environmental impact in sensitive areas



Palm Beach
- Total UG cost would be $60 million

- MUUC Report
  - Difference of UG vs. hardened OH is $835,000 per mile

Source: InfraSource

Conclusions Regarding Insights for Modeling

Assessment of Proposed Projects

- Construction cost models are adequate
- Maintenance cost models are adequate
- Storm reliability models are inadequate
  - Equipment hurricane failure rates are not well known
  - The effects of mitigation tactics are not well known
  - Detailed hurricane simulation planning models do not exist

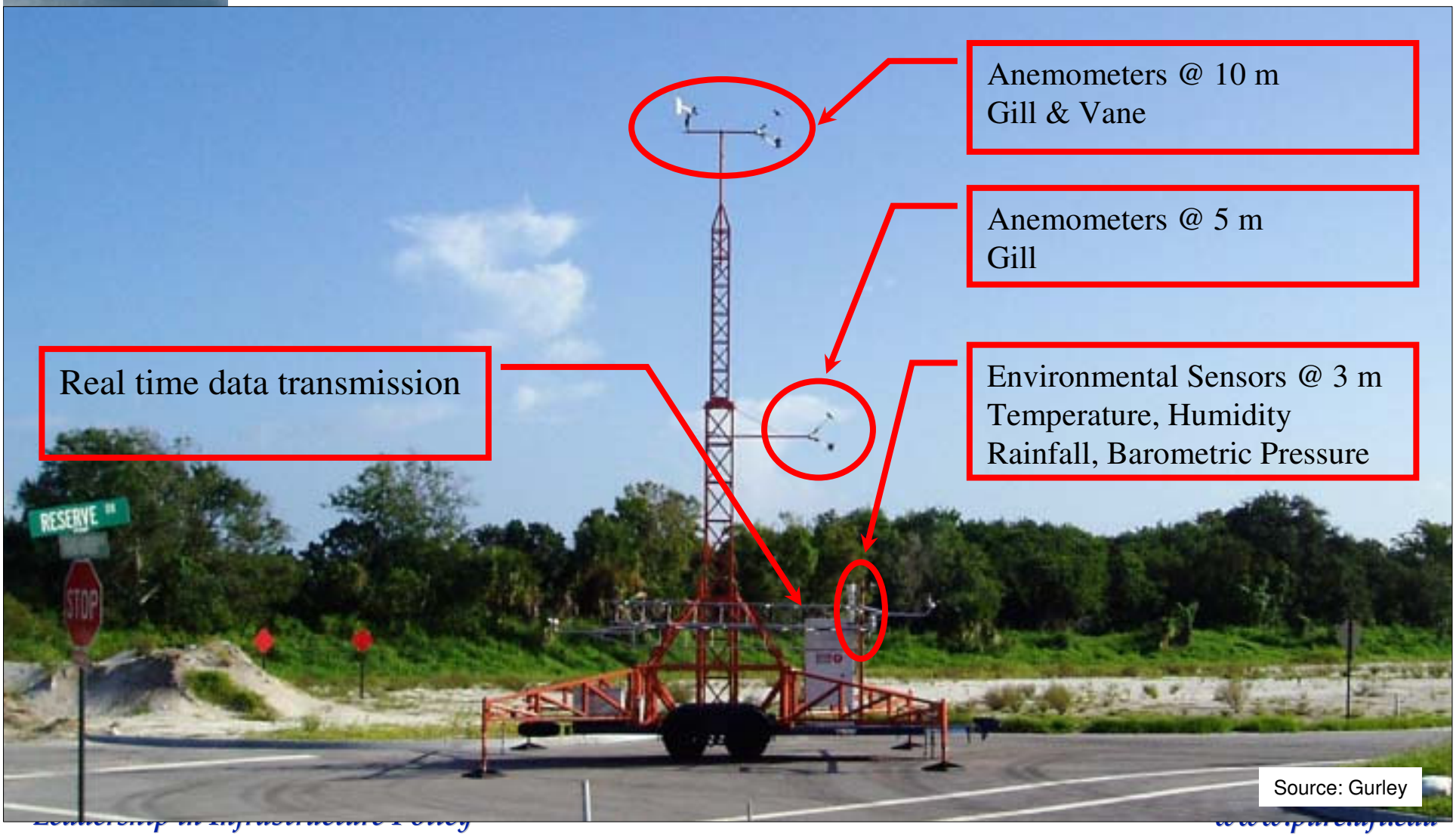
Timeline

- Case studies
  - August 6, 2007 – Final Report
- Computer model development
  - October 1, 2007 – Final Report on methodology
  - March 30, 2008 – Model and testing completed

Wind Research

- Coordinated effort of UF Civil Engineering, WeatherFlow, Utility Sponsors, and PURC
- Purpose: Measure hurricane winds at granular level and map to infrastructure damage
  - Forensic Analysis
  - Test using hurricane simulator

FCMP TOWERS


Anemometers @ 10 m
Gill & Vane
Anemometers @ 5 m
Gill
Real time data transmission
Environmental Sensors @ 3 m
Temperature, Humidity
Rainfall, Barometric Pressure
RESERVE
STOP
Source: Gurley

Motivation for Portable Towers

- Winds overland differ from winds over the ocean (over water is the basis for SS-scale)
- Mean speed is lower and turbulent gusts are more severe in winds overland
- Can't fix a problem without understanding the cause
- Evaluation of infrastructure vulnerability (and hardening solutions) must start by filling this knowledge gap via direct wind measurements

Questions to Address

- How do we know what winds have really caused damage?
- How do we know what winds the infrastructure has actually withstood?

Existing Portable Weather Stations




- Stiff 10-m Steel Lattice Tower
- Remain stable in 200 mph winds
- Self-powered

- Instruments collect wind speed and environmental data
- Quick setup to hasten retreat from approaching storm

Source: Gurley

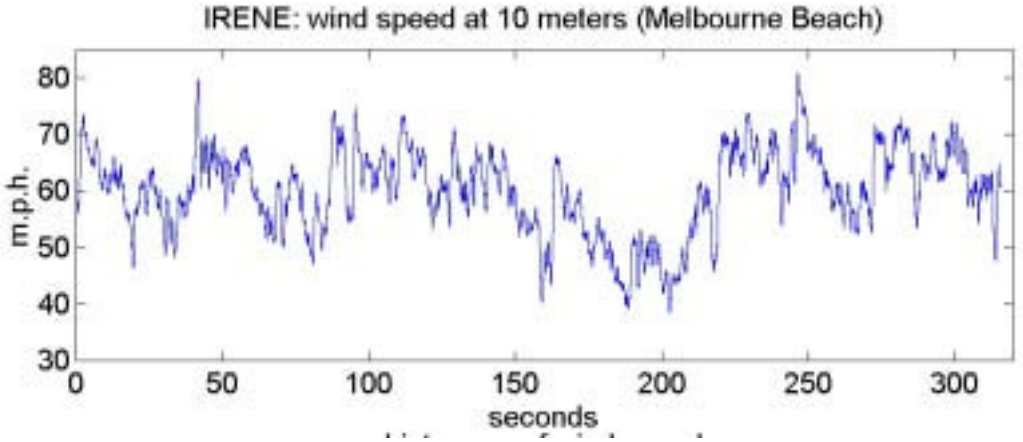
New Fixed Weather Stations

- Developed, placed, and managed by WeatherFlow http://www.weatherflow.com/index.php

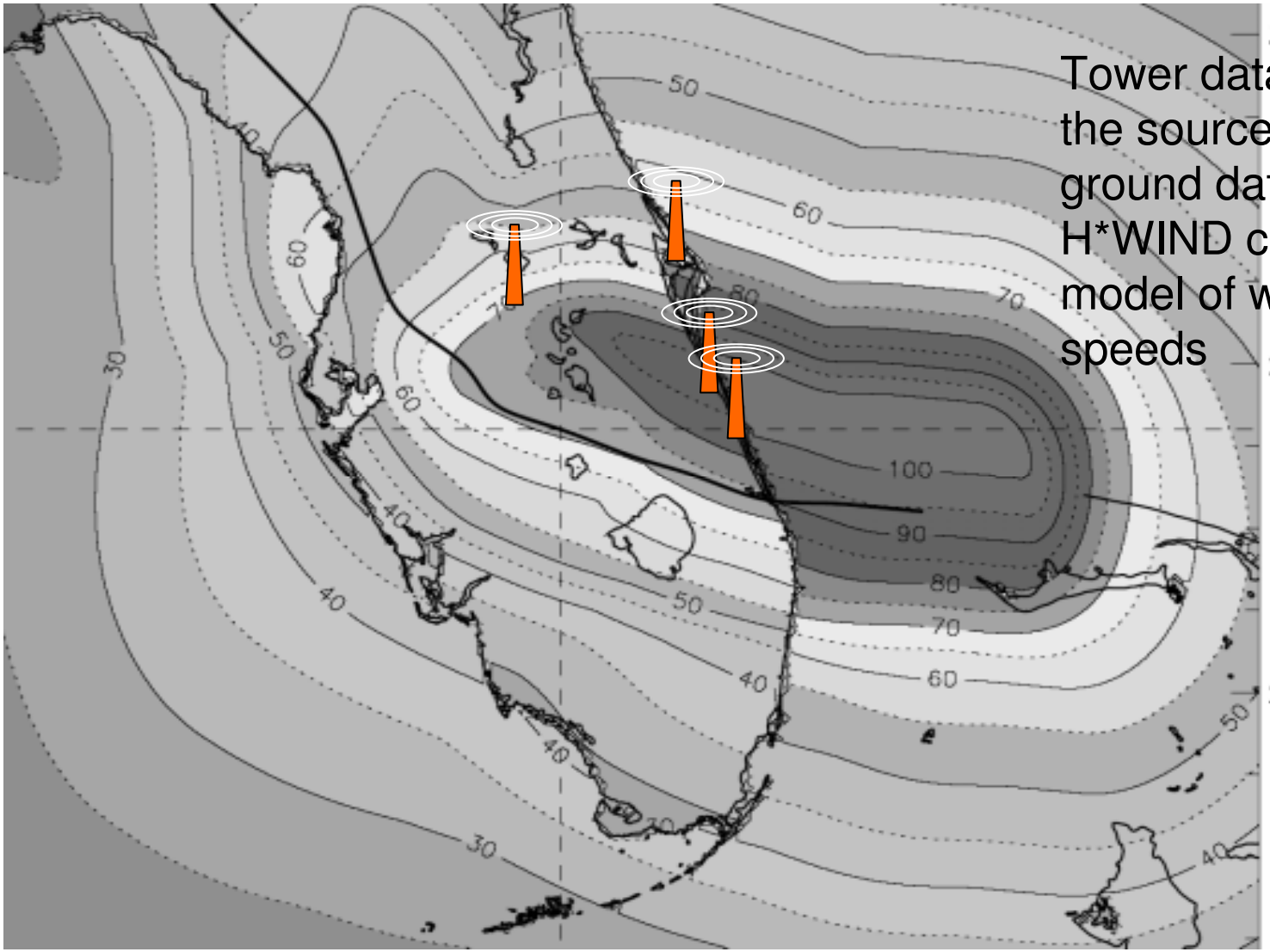
  - Tested and upgraded by UF Civil Engineering, Kurt Gurley
- Currently 12 stations
  - Anticipating 40

Wind Station Uses

- Monitor wind, barometric pressure, temperature 24/7/365
- Data to sponsors, UF, PURC, NOAA on proprietary basis
  - Forensic analysis and NOAA maps



NOAA Hurricane Research Division Maximum Sustained Wind Swath



Tower data is one of the sources of ground data input to H*WIND contour model of wind speeds

Hurricane Jeanne (2004)

Source: Gurley

Capacity testing without a hurricane

- Housing infrastructure can be tested under applied controlled loads to evaluate failure strength
- Same concept can be applied to power distribution infrastructure

FIELD TESTING – ROOF CONNECTIONS

- Test as-build capacity
- Install retrofit
- Test retrofit capacity
- Relate forces to winds
- Evaluate effectiveness

Source: Gurley

FIELD TESTING - SHEATHING CAPACITY

- Cut out sheathing and trusses
- Apply suction load until failure
- As-nailed
- Re-nailed

Source: Gurley

Vegetation Management

- Best Practices workshop, March 5-6, 2007
  - Report available online
  - http://bear.cba.ufl.edu/centers/purc/energy/hurricane.htm
  - Selected key conclusions
    - Laws needed for utility access
    - Better communications are needed
    - Not directly relevant to hurricanes

Conclusions

- Collaborative research has been a success thus far
  - Good projects initiated and sound results
  - Utilities working together and supportive of effort is critical
  - Many of the research questions are applied, so academic research is needed only in selected areas